Integrating Nanoscale Science and Engineering into the Undergraduate Engineering Curriculum

Prof. Wendy Crone, Dr. Ken Lux, Prof. Robert Carpick,
Engineering Physics
Prof. Don Stone, Prof. Eric Hellstrom,
Materials Science and Engineering

University of Wisconsin - Madison

THE UNIVERSITY of WISCONSIN MADISON

MRSEC

Materials Research Science and Engineering Center
on Nanostructured Materials and Interfaces

Interdisciplinary Education Group

NATIONAL SCIENCE FOUNDATION

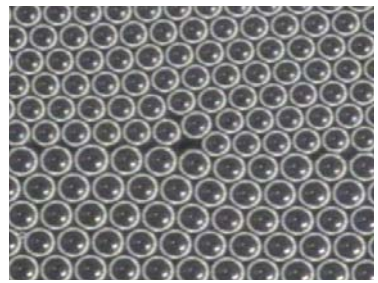
UW-Madison NUE Activity

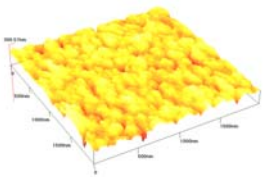
- Our work integrates nanoscale science and engineering educational modules into key introductory and advanced undergraduate courses in the College of Engineering at the University of Wisconsin – Madison.
- The six courses targeted for modification range from freshman introductory courses to advanced level materials and mechanics courses.
- Most of the modifications focus on removing outdated content and replacing it with new cutting-edge content based on current research and emerging applications in nanotechnology.

***Introduction to Engineering* (EPD 160)**

***Introduction to Modern Materials* (MSE 250)**

***Materials Laboratory II* & III (MSE 361 & 362)**





***Advanced Mechanical Testing of Materials* (EMA 611)**

***Micro- and Nanoscale Mechanics* (EMA 601)**

THE UNIVERSITY of WISCONSIN MADISON

MRSEC

Materials Research Science and Engineering Center
on Nanostructured Materials and Interfaces

Interdisciplinary Education Group

NATIONAL SCIENCE FOUNDATION

A Course in Micro- and Nanoscale Mechanics

Spring 2003

Micro- and Nanoscale Mechanics

Instructors: W.C. Crone and R.W. Carpick

Tue./Thurs. 11:00-12:15p

EMA 601 (Lecture 3)

Class #51123

3 credits

Course Description:

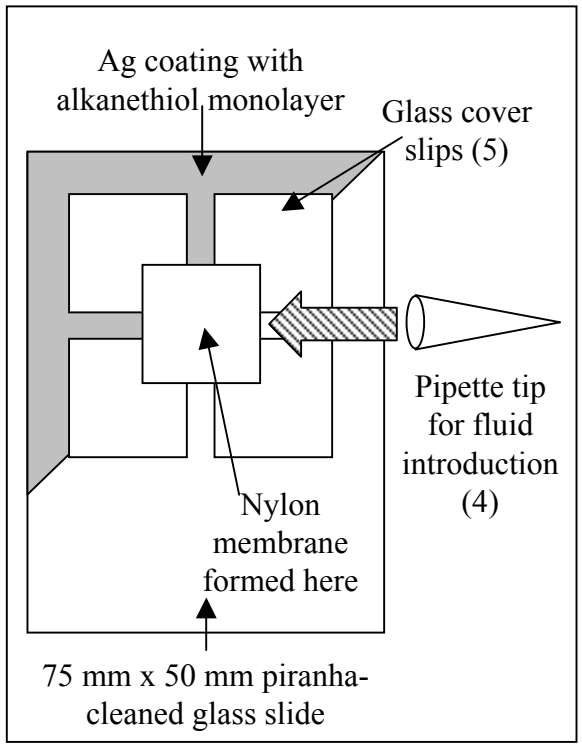
This course will provide an introduction to nanoscale engineering with a direct focus on the critical role that mechanics needs to play in this developing area. Engineering is progressing to ever-smaller scales, enabling new technologies, materials, devices, and applications. Mechanics enters a new regime where the role of surfaces, interfaces, defects, material property variations, and quantum effects play more dominant roles. We will discuss how mechanics becomes integrated with the fields of materials science, chemistry, physics, and biology at this scale. We will cover a variety of concepts and applications, drawing connections to both established and new mechanics approaches. We will discuss the limits of continuum mechanics and present newly developed mechanics theories and experiments tailored to describe micro- and nano-scale phenomena. We will emphasize specific applications throughout the course.

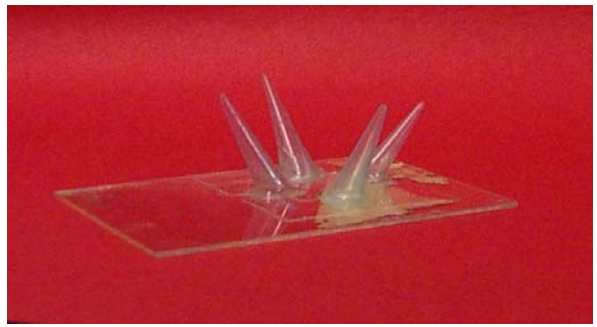
Prerequisites:

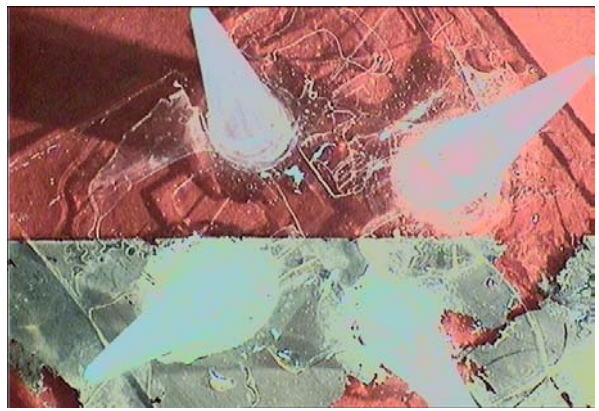
Students should have a general understanding of mechanics and materials, and a deep curiosity in extending their knowledge beyond traditional bounds. This course is open to graduate students and advanced undergraduates, but it is designed for students willing and able to work at least at the level of a first year graduate student. Literature reviews, critical peer discussion, and student presentations will be an integral part of the course.

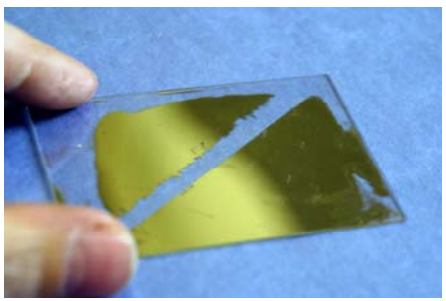
Course Web Page:

http://www.engr.wisc.edu/ep/ema/courses/ema601micronano.html







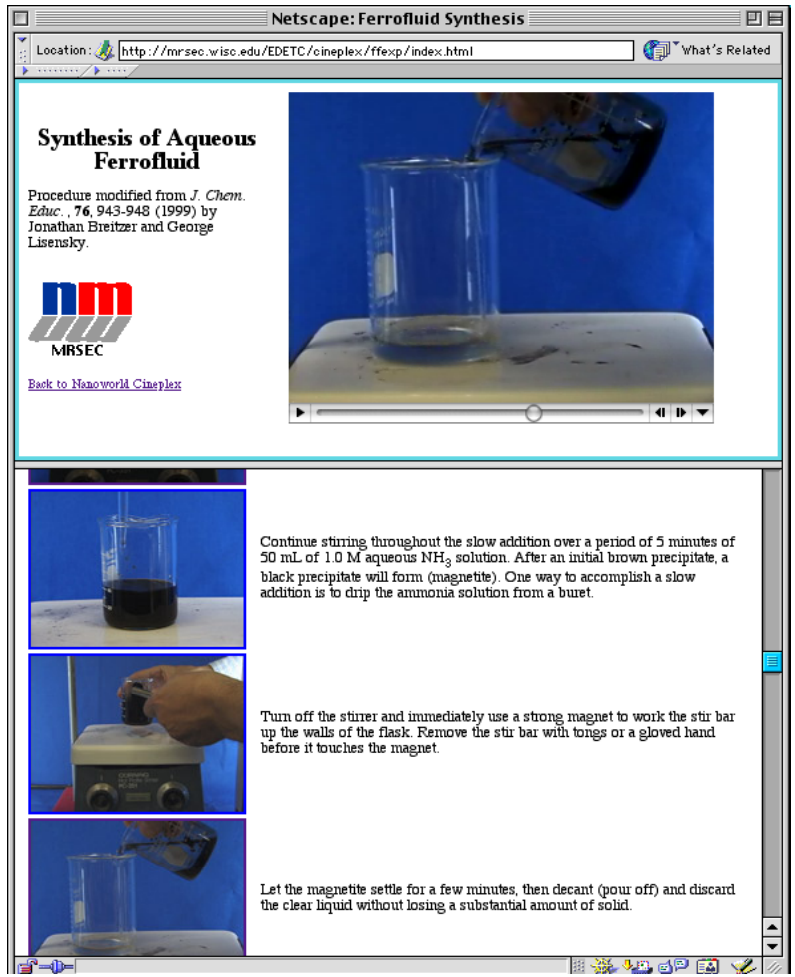


Web-Based Education Tools

Nanotechnology Lab Manual

Nanoworld Cineplex Demonstrations

http://www.mrsec.wisc.edu/nano



THE UNIVERSITY of WISCONSIN MADISON

MRSEC

Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces

Interdisciplinary Education Group

NATIONAL SCIENCE FOUNDATION

Benefits of a Video-based Lab Manual

Can be utilized as:

- Video replacement for traditional lab manual
- Lab access for disabled students
- "Stand-alone" demo
- Can avoid the use of toxic materials

THE UNIVERSITY of WISCONSIN MADISON

MRSEC

Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces

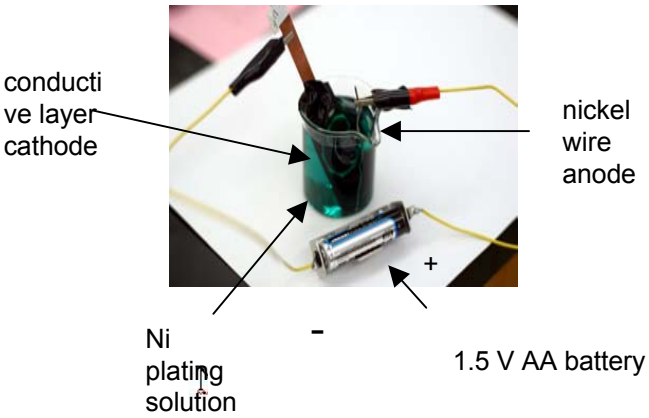
Interdisciplinary Education Group

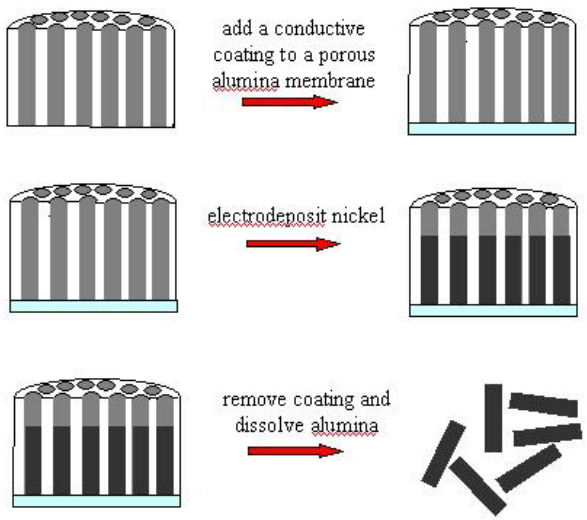
NATIONAL SCIENCE FOUNDATION

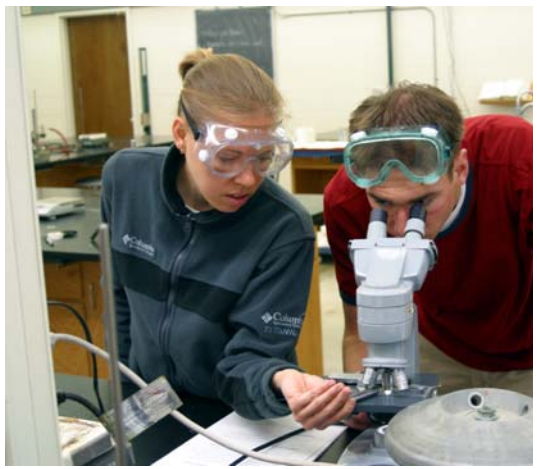
Laboratory Development Process

- Topics chosen from research-based nanotechnology concepts
- Identification of target audience
- Reliability
  - Modify procedures for consistent results
- Modifications
  - Address needs and limitations of classroom environment (*e.g.* time, cost, equipment, safety)
- Assess and Update

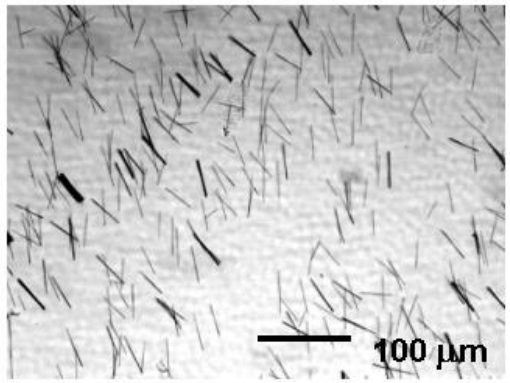
Nickel Nanowire Synthesis

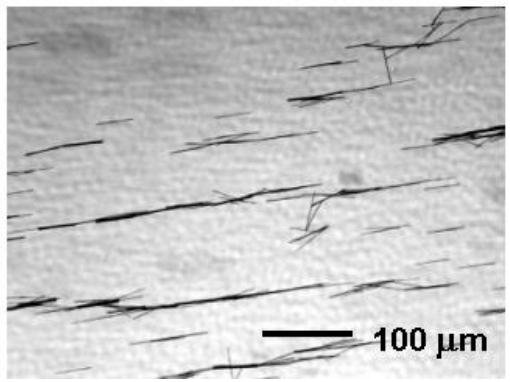






optical microscope
20X magnification





THE UNIVERSITY of WISCONSIN MADISON

MRSEC

Materials Research Science and Engineering Center
on Nanostructured Materials and Interfaces

Interdisciplinary Education Group

NATIONAL SCIENCE FOUNDATION

Nickel Nanowire Lab Assessment

Milwaukee School of Engineering (MSOE)	Chemistry 200 (a second quarter general chemistry course for engineering students)	3 of 12 pairs made nanowires successfully
UW-Madison	MS&E 361 (a sophomore level materials laboratory)	5 of 9 pairs
UW-Madison	Chemistry 311 (an intermediate inorganic chemistry course)	23 of 24 pairs

"Nano stuff isn't as 'mystical' as it seems."
-- *MSE 361 student*

"I liked the fact that this lab had a direct correlation to current research."
-- *Chem 311 student*

"I found out that basic chemistry can be used to make something so small."
-- *Chem 311 student*

Impact

- Approximately 400 engineering students will be impacted in the first year of implementation on the UW-Madison campus.
- The educational tools developed will be disseminated through a variety of mechanisms including
  - *Laboratory Manual for Nanoscale Science and Technology* http://www.mrsec.wisc.edu/edetc/nanolab/index.html
  - Nanoworld Cineplex http://www.mrsec.wisc.edu/edetc/cineplex/index.html

Acknowledgements

- National Science Foundation
  - Nanotechnology Undergraduate Education grant (award # EEC-0304479) jointly funded by the Division of Civil and Mechanical Systems (CMS) and the Division of Chemical and Transport Systems (CTS) in the Directorate for Engineering (ENG) and the Division of Materials Research (DMR) in the Directorate for Mathematical and Physical Sciences (MPS)
  - Materials Research Science and Engineering Center (MRSEC) on Nanostructured Materials and Interfaces (award # DMR-0079983)
  - CAREER Awards to Wendy Crone (award # CMS-0134385) and Robert Carpick (award # CMS-0134571)
  - Graduate Research Fellowship to Anne Bentley

THE UNIVERSITY of WISCONSIN MADISON

MRSEC

Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces

Interdisciplinary Education Group

NATIONAL SCIENCE FOUNDATION